

# **The Economics of Prohibition: Price, Consumption and Enforcement Expenditures during Alcohol Prohibition**

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## Abstract

It is commonly believed that alcohol Prohibition in the early 1900s was effective in reducing alcohol consumption. This study shows that although Prohibition had significant effects on alcohol consumption right after its enactment, it had little or no effects on alcohol consumption in the long run. Alcohol consumption fell immediately after the enactment of Prohibition to roughly 30 percent of its pre-Prohibition level and rose to 70 percent of its pre-Prohibition levels by 1929 (and was still rising). The implied percentage increase in alcohol price, including the premium for breaking the law, decreased from 318 percent in 1921 to 171 percent of pre-Prohibition level in 1929. Simultaneously, enforcement costs rose from \$2.2 million in 1921 to \$10 million in 1925 and to \$13.4 million in 1930. In general, Prohibition created a black hole for enforcement expenditures. As the black market adjusted to law enforcement practices (by improved technology, innovation and bribery), consumption rose even as enforcement expenditures increased. Therefore, Prohibition had an immediate, but not enduring impact, on the level of alcohol consumption and price.

## **Introduction**

Alcohol Prohibition in the US began in January 1920 and was repealed in December 1933. This “noble experiment”<sup>1</sup> was undertaken to reduce the consumption of alcohol, to reduce crime, as well as to solve other social problems. The results of that experiment indicate that it was a miserable failure. Evidence from this “noble experiment” affirms sound economic theory, which predicts that Prohibition of mutually beneficial exchanges is doomed to be failure.

The lessons from Prohibition remain important today. These lessons apply not only to the debate over the war on drugs but also to the mounting efforts to drastically reduce access to alcohol and tobacco. Evidence from the Prohibition era has shown that although the cost of Prohibition increased from 2.2 million dollars in 1920 to over ten million dollar in 1925 and to about fourteen million in 1930, it did not reduce consumption significantly. Contrary to common belief, Prohibition did not reduce demand for alcohol in the long-run.

In this paper we will first discuss both short-run and long-run effects of Prohibition on alcohol prices. Second, we will analyze different market structures under Prohibition. Third, we will document relationship between enforcement costs and prices. Finally, we will briefly discuss Becker-Murphy’s (1988) rational addiction model and its predictions on demand and prices of illegal goods.

## **Effects of Prohibition on Alcohol Prices**

Since alcohol was prohibited during that period, accurate data for alcohol consumption and prices are not available. However, there are a few good studies of

alcohol consumption under Prohibition. In this paper, we use data from Miron and Zwiebel (1991) and Warburton (1968). According to Miron and Zwiebel, aggregate alcohol consumption fell immediately after the enactment of Prohibition to 30 percent of its pre-Prohibition level in 1921. However, alcohol consumption rose to about 60-70 percent of its pre-Prohibition level during the next several years. Miron and Zwiebel use mortality, mental health and crimes statistics to estimate the consumption<sup>2</sup>.

Warburton uses agricultural sources of production, death rates and arrests for drunkenness in estimating consumption, and he assumes linear relationships between alcohol consumption and various statistics. He estimates that consumption per capita is around 65 percent of pre-Prohibition levels by 1925 and around 71 percent by 1929. Although Miron and Zwiebel's estimates are slightly higher than Warburton's, they acknowledge that on average their estimates are about the same as Warburton's.

Table 1 shows the consumption of alcohol beverages during Prohibition estimated by Warburton. Although per capita spirits consumption decreased to 35 percent of pre-Prohibition level in 1921, it increased to 233 percent of pre-Prohibition level in 1925 and by 1929, it rose to 242 percent of pre-Prohibition level.<sup>3</sup> Whereas, beer consumption decreased to 19 percent of pre-Prohibition level in 1921 and rose to about 43 percent of pre-Prohibition level on 1925 and to about 89 percent in 1929<sup>4</sup>.

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<sup>1</sup> This term was used by Fisher (1930).

<sup>2</sup> Unlike Warburton, they assume log linear relationship between alcohol consumption and various statistics that enable the restriction that no alcohol consumption should imply no deaths from alcoholism, no alcoholic psychosis and no drunkenness arrests. The series that they use to estimate alcohol consumption are the death rate from cirrhosis of the liver, the death rate from alcoholism, the number of patients per capita admitted to hospitals for the first time with alcoholic psychosis and the rate of drunkenness arrests.

<sup>3</sup> We use 1919 as base year. Even if we use other year other than 1919, the pattern of consumption will still be the same.

<sup>4</sup> Here, we use 1919 as base year. If we use other year other than 1919, the percentage increase will be less although beer consumption will still be increasing in the later years of Prohibition.

Wine consumption, however, was rather interesting. Prohibition led to an increase in illegal and home-made wine production. Although wine consumption decreased to about 86 percent of pre-Prohibition level in 1921, it increased to about 168 percent of pre-Prohibition level in 1925 and to about 175 percent of pre-Prohibition level in 1929.

Table 1  
Consumption of Alcoholic Beverages in the United States<sup>5</sup>  
1921 to 1930

Year	Millions of gallons			Gallons per capita		
	Spirits	Wine <sup>6</sup>	Beer <sup>7</sup>	Spirits	Wine	Beer
1921	33	48	136	.30	.44	1.26
1922	169	68	188	1.54	.57	1.71
1923	219	106	250	1.96	.95	2.24
1924	198	102	321	1.75	.90	2.84
1925	207	99	398	1.80	.86	3.46
1926	223	122	490	1.91	1.05	4.21
1927	181	128	595	1.53	1.08	5.03
1928	210	128	726	1.75	1.07	6.05
1929	226	108	864	1.86	.89	7.11
1930	164	107	850	1.33	.87	6.90

Source: Warburton 1968, 71

Since Prohibition was a supply-reduction policy, it made more difficult for producers to supply bulky products (such as beer) to market. It is shown in above statistics. Under Prohibition, consumption of higher potency alcohol products increased relative to low-potency alcohol products.<sup>8</sup> Fisher also notes that “Prohibition has been more effective in suppressing the drinking of beer than of whiskey” (1927, 29). Although

<sup>5</sup> The estimates for spirits are in terms of gallons of 50 percent alcohol, by volume. Since spirits are usually sold, or at least drunk, in weaker solutions than this, the consumption in ordinary gallons is considerably larger than the figures in the table.

<sup>6</sup> The estimates are from illegal and home-made wine produced in the United States plus that removed from bonded wineries.

<sup>7</sup> Beer produced plus smuggled beer minus malt liquors seized.

<sup>8</sup> Prohibition had little impact on demand since it did not change tastes or incomes of the consumer directly. As supply of bulky goods decreased due to fear of being caught, demand shift to close substitutes. Once Prohibition was repealed, the pre-Prohibition expenditure patterns for both high- and low- potency alcohol reemerged. It appears that the dramatic change in potency of prohibited drugs is directly related to

Prohibition reduced the aggregate alcohol consumption in short-run, it could not reduce consumption significantly in the longer run, in fact, it shifted consumption pattern from “soft” to “hard liquor” as shown above.

The immediate decrease in consumption resulted from two forces. First, the supply cost of alcoholic beverages increased (including expected penalties for breaking the laws). Second, the consumers had to pay “price premium” associated with the expected risk of being caught. Right after the enactment of Prohibition, producing, marketing and distribution of alcoholic beverages became very risky for suppliers. As a result, prices of alcoholic beverages increased and supply decreased.

In order for us to analyze further, we need to look at historical data of alcohol consumption.

Table 2  
Per-Capita Consumption of Alcohol Beverages in Gallons, 1909-1919

Year	Spirits	Wines	Beer	Total Alcohol	Total Pure
1909	1.32	0.67	19.04	21.03	1.56
1910	1.42	0.65	19.77	21.84	1.64
1911	1.46	0.67	20.69	22.82	1.70
1912	1.45	0.58	20.02	22.05	1.66
1913	1.51	0.56	20.72	22.79	1.71
1914	1.44	0.53	20.69	22.66	1.67
1915	1.26	0.33	18.40	19.99	1.46
1916	1.37	0.47	17.78	19.62	1.51
1917	1.62	0.41	18.17	20.20	1.64
1918	0.85	0.49	14.87	16.21	1.13
1919	0.77	0.51	8.00	9.28	0.80

Source: Warburton 1968, 24

Alcohol consumption is related to some variables such as income, price, and alcohol taxes. A Historical perspective on alcohol consumption is illustrated in table above. It shows that the consumption of beer increased throughout 1909-1918 although

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prohibition itself. The decrease in average potency over time of legal drugs, such as caffeine, nicotine and alcohol reinforces this proposition (Ippolitio, Murphy and Sant 1979).

the consumption of pure alcohol was quite stable during the period. However, more money was being spent on beer than on spirits. This pre-Prohibition pattern was reestablished after the repeal of Prohibition, distilled spirits again accounting for only about half of all alcohol expenditures (42-53 percent of total alcohol sales during the period of 1939-60).

During Prohibition (1922-30) expenditures for distilled spirits as a percentage of all alcohol expenditures rose to 70-90 percent. The evidence from the past has shown that Prohibition has changed the relative prices of different alcohol beverages and that led to increased consumption of higher-potency drugs. Consequently, the demand for low potency drugs decreased (e.g. beer) and the demand for high potency drugs increased (e.g. spirits). In fact, Prohibition had little or no effect on the total demand of alcohol.

### **Real Income and Prices**

Empirical evidence shows that aggregate real income increased throughout Prohibition period, and this increase in income should have led to an increase in the quantity demand. In contrast, the actual quantity demanded decreased between 1920 and 1921. Then, in the later Prohibition period, while aggregate real income levels increased by a few percentage points, the quantity demanded rose significantly. Hence, a decrease in price contributed to an increase in quantity demanded during the later part of Prohibition period.

The accurate prices of alcohol are not available simply because it was illegal. However, there are a few estimates of alcohol prices during Prohibition. Fisher's alcohol price index shows that average increase in alcohol price is about 360 percent between

1916 and 1928 (Fisher 91). According to Warburton's data, average alcohol consumption increased to about 240 percent of 1918 level in 1921, to about 165 percent of 1918 level in 1925 and to about 140 percent of 1918 level in 1929 (Warburton 148-161).<sup>9</sup>

Table 3

The following table shows implied alcohol Price during Prohibition.<sup>10</sup>

<u>Year</u>	<u>Actual Quantity Index*</u>	<u>Aggregate Real Income**</u>	<u>Implied Price<sup>11</sup></u>
1919	100	61	\$ 1.00
1921	30	64	3.45
1925	65	78	1.82
1929	71	85	1.78

Note: \*Consumption in year/consumption in 1919

\*\* Real income in billions of 1929 dollar

An examination of the Prohibition on alcohol during the 1920s provides useful and interesting evidence on long-run alcohol prices. Table 3 implies that in the longer run, the alcohol industry adjusted in ways that reduced the risks of being punished for criminal provisions, as a result, the prices of alcoholic beverages decreased. Suppliers also learned to produce, recruit and sell more efficiently due to induced technological change (innovation) in the longer run. That was precisely what happened in the later part

<sup>9</sup> Warburton has estimated price of alcoholic beverages during Prohibition and 1918 wholesale prices for beer, spirits, and wine. To calculate percentage change, we simply calculated percentage change

<sup>10</sup> For the calculations we used an income elasticity of demand  $e_y = 0.7$  and a price elasticity of demand  $e_d = -1.0$ . These estimates were rough averages of the following studies:

Ornstein and Hanssens (1981):  $e_d = -1.0$ ,  $e_y = 0.5$

Cook and Tauchen (1982):  $e_d = 0$  to  $-2.0$ ,  $e_y = 0.43$

Godfery (1988):  $e_d = -0.61$  to  $-0.84$ ,  $e_y = 1.34$  to  $2.09$

Calculation for implied prices are provided in Appendix one.

of alcohol Prohibition in the US. Producers learned to improve technology and supply more (see table 1).

### **Enforcement Cost**

The U.S government spent billions of tax dollar for enforcing Prohibition since Prohibition without enforcing the law was not Prohibition. The ultimate goal of prohibition was to eliminate supply of alcohol. The marginal cost of prohibiting one unit of alcohol was the cost the law enforcement necessary to bring about this result. Every dollar spent on prohibition enforcement means one less dollar that can be spent on alternative public policies such as education. To analyze the effectiveness of law enforcement, we look at federal government's expenditures and alcohol prices during Prohibition.<sup>12</sup>

**Table 4**  
Federal Expenditures upon the Enforcement of Prohibition<sup>13</sup>  
(thousands of dollars)

Year ending June 30	Direct cost		Indirect <sup>14</sup> Cost	Less fines and penalties	Total net expenditures
	Bureau of Prohibition	Coast Guard			
1920	2,200	.....	1,390	1,149	2,441
1921	6,350	.....	5,658	4,571	7,437
1922	6,750	.....	7,153	4,336	9,547
1923	8,500	.....	10,298	5,095	13,703
1924	8,250	.....	10,075	6,538	12,093
1925	10,012	13,407	11,075	5,873	28,621
1926	9,671	12,479	10,441	5,647	26,944
1927	11,993	13,959	11,482	5,162	32,272
1928	11,991	13,667	16,930	6,184	36,404
1929	12,402	14,123	16,839	5,474	37,890
1930	13,374	13,558	17,100	5,357	38,675

Source: Warburton 1968, 246

<sup>11</sup> Risk cost is included in implied price.

<sup>12</sup> If law enforcement were effective, it would have kept prices of alcohol high enough from consuming.

<sup>13</sup> There is no evidence that suggests that state and local governments spent large sums during Prohibition greater than they spent formerly on regulatory or prohibitory laws. The states have spent about seven hundred thousand dollars a year in the direct enforcement of prohibition but their indirect expenditures, as well as the expenditures of local governments, are difficult to estimate (Warburton 1968).

<sup>14</sup> The indirect cost included such expenditures as the costs of criminal prosecutions.

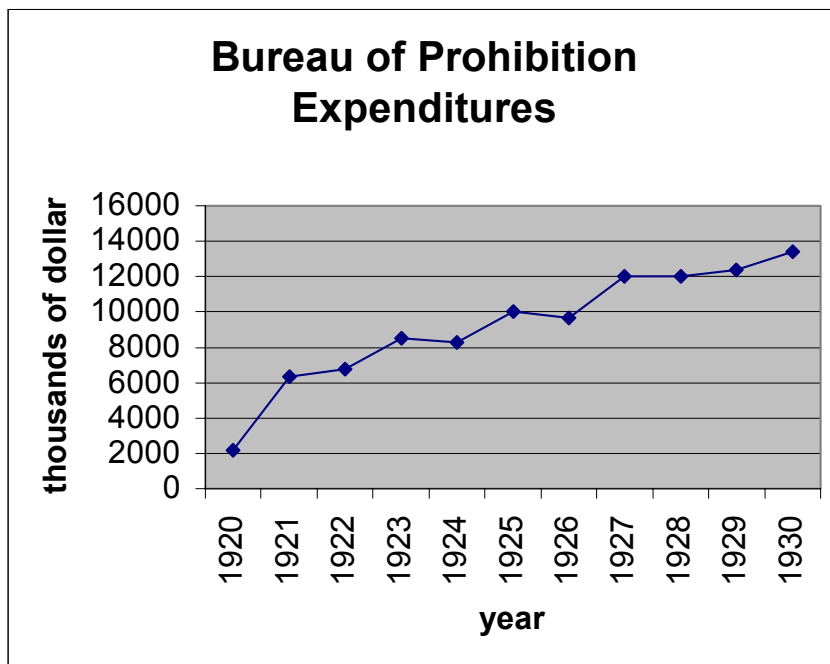
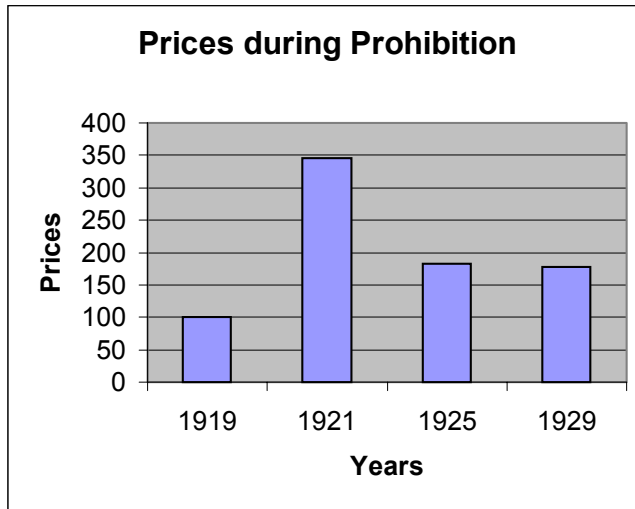
Expenditures for the Coast Guard started only in 1925 when people learned to smuggle hard liquor in from foreign countries especially from Canada. In 1920, the Bureau of Prohibition (not including the Coast Guard and indirect cost) spent 2.2 millions, in 1925 was about 10 millions and by 1930 Prohibition cost increased to 13.37 millions. Meanwhile, total expenditures grew from less than four million dollars in 1920 to almost forty-five million in 1930.<sup>15</sup> We find that although the federal government's expenditures increased significantly throughout Prohibition, prices of alcohol declined over time. Increased government expenditures have failed to keep prices high and reduce the supply the alcohol in the long run. Fines and penalties provide some evidence of the effectiveness of law-enforcement resources. However, this effectiveness appears to have been weakened by the development of specialists in illegal production, the development of rigidities within the bureaucracy, and the corruption of public and law-enforcement officials (Thornton, 1991).<sup>16</sup> The graphs below show the relationship between law enforcement expenditures and alcohol prices during Prohibition.

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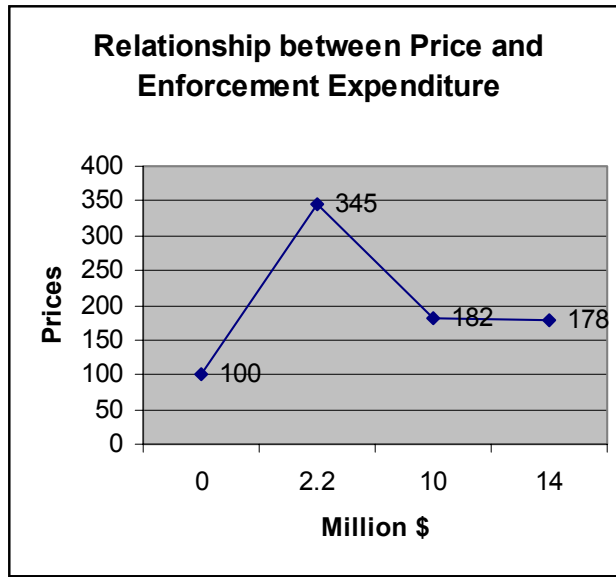
<sup>15</sup> Bureau of Prohibition expenditures, coast guard and indirect costs were included in total cost.

<sup>16</sup> The police officials may even become actively involved in the management and maintenance of the monopoly, in fact, police may condone or participate third parties in the pursuit of maintenance of the monopoly and its profits (Thornton 1991, 91). As enforcement efforts increase, corruption will gain a comparative advantage in avoiding detection over transportation, technology and deception.

Graph 1: Prices during Prohibition



Graph 2: Bureau of Prohibition Expenditures



Graph 3: Relationship between Enforcement Cost and Alcohol Prices

### Competitive Case

As street price increased, there was a big wedge between street price ( $P_s$ ) and production price ( $P_p$ ), and that wedge was risk cost ( $\rho$ ) for producing and selling alcohol.

$$P_s = P_p + \rho$$

Risk cost or expected fine ( $E(F)$ ) in turn is a function of fine ( $F$ ) (both monetary and non-monetary punishment), law enforcement expenditure ( $E$ ) and quantity of alcohol ( $Q$ ) when they were buying or selling. Therefore, it can be written as:

$$E(F) = F \cdot \pi(E, Q)$$

In the equation above, fine, enforcement expenditures and quantity are positively related to risk cost, and probability of being caught ( $\pi$ ) increases as enforcement and quantity increases, meaning that risk cost increased as fine, enforcement expenditures and quantity of alcohol supplied increased under Prohibition. Also, probability of being caught increased as enforcement expenditures and quantity of alcohol supplied increased.

Hence, as the consequence of enforcing the Prohibition, street prices rose significantly, and cost and marginal cost to suppliers became

$$C = C(Q) + E(F)$$

$$MC = C'(Q) + F \frac{\partial \pi}{\partial Q}$$

Increased enforcement therefore, increases the ratio of costs of risks to the cost of production. The result is an increased profit opportunity for entrepreneurship in avoiding detection. The big wedge in gross price and net price led to innovation in the market. In other words, suppliers found ways to avoid risk, and it was equivalent to Research and Development (R&D) in legal goods. This R&D led to technological change in producing, importing and supplying consumers. Therefore, research (R) can be written as

$$R(P_G - P_N)$$

As the wedge between gross price and net price increased, research and development by different suppliers increased and this in turn increased the knowledge (K). Thus, probability of being caught became a function of enforcement expenditures, quantity and knowledge. As knowledge increased, probability of being caught decreased and knowledge would increase as research increased.

$$\pi (E, Q, K)$$

Also probability of being caught is a function of time. It means that as time goes on probability of being caught decreases as knowledge increases.

$$\pi (E, Q, t); \frac{\partial \pi}{\partial E} > 0, \frac{\partial \pi}{\partial Q} > 0, \frac{\partial \pi}{\partial t} < 0$$

### **Imperfect Competition: The Emergence of a Dominant Supplier Case**

As knowledge increases with time, one supplier with comparative advantage has a major share of total sales and a group of smaller suppliers supply the remainder of the market. The large supplier then acts as a dominant supplier, setting a price that maximizes its own profits. The other suppliers, which individually could have little influence over price would then act as perfect competitors. They take the price set by the dominant supplier as given and produce accordingly. However, unlike monopoly supplier, in order for a dominant supplier to maximize profit, it must take into account how the output of the other suppliers depend on the price it sets.

The figure 2 shows how a dominant supplier sets its price<sup>17</sup>. Here,  $D$  is the market demand curve, and  $S_f$  is the supply curve (i.e., the aggregate marginal cost curve of the smaller fringe suppliers). The dominant supplier must determine its demand curve  $D_d$ . As the figure shows, this is just the difference between market demand and the supply of the fringe suppliers. For example, at price  $P_1$  the supply of fringe suppliers is just equal to market demand, so the dominant supplier can sell nothing at this price. At a price  $P_2$  or less, fringe suppliers will not supply any of the good, so the dominant supplier faces the market demand curve. At prices between  $P_1$  and  $P_2$ , the dominant supplier faces the demand curve  $D_d$ .

Corresponding to  $D_d$  is the dominant supplier's marginal revenue curve  $MR_d$ .  $MC_d$  is the dominant supplier's marginal cost curve. To maximize its profits, the dominant supplier produces quantity  $Q_d$  at the intersection of  $MR_d$  and  $MC_d$ . From the demand curve  $D_d$ , we find price  $P_e$ . At this price, fringe suppliers sell a quantity  $Q_f$ , so that the total quantity sold is  $Q_t = Q_d + Q_f$ .

In figure 3, risk costs were added to both the dominant and fringe suppliers. The dominant supplier, who has a comparative advantage over fringe suppliers, encounters a lower risk. However, fringe suppliers have a higher risk cost of staying in the market. Figure 3 shows that when risk cost is added, fringe suppliers supply much less than before and the dominant supplier supply more than before.

### **Monopoly Case**

A dominant supplier that has a comparative advantage in avoiding law enforcement over other firms becomes a monopoly supplier in the longer run.<sup>18</sup> Figure 4 shows that risk cost for fringe suppliers becomes very high that at equilibrium price  $P_e$ , only the dominant supplier supplies to the market.

Monopoly power implies that price exceeds marginal cost (including risk cost), however, monopoly supplier chooses price and output so that marginal revenue equals marginal cost. To do this, we first rewrite the expression for marginal revenue:

$$MR = \frac{\Delta R}{\Delta Q} = \frac{\Delta(PQ)}{\Delta Q}$$

The extra revenue from an incremental unit of quantity (far right term) has two components. Producing one extra unit and selling it at price  $P$  brings in revenue  $(1)(P)=P$ . But a supplier faces a downward-sloping demand curve, producing and selling

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<sup>17</sup> This figure is taken from Pindyck and Rubinfeld (1995).

<sup>18</sup> Increase in R&D led to increase in monopoly under Prohibition. One big supplier became a monopoly supplier in the sense that it controlled the majority of the market and had all the advantages that a monopoly firm had. Benjamin and Miller (1991) states that the marketing of illegal commodities is the perfect breeding ground of criminal organizations and organized crime. In the later part of Prohibition, a monopoly supplier had comparative advantage in dealing with importing, producing and supplying alcohol, and it learned to bribe the law enforcement officials. Criminal organizations themselves were a form of advertising and recruiting for illegal substances.

this extra unit also results in a small drop in price  $P/Q$ , which reduces the revenue from all units sold (i.e., a change in revenue  $Q(\Delta P/\Delta Q)$ ). Hence,

$$MR = P + Q \frac{\Delta P}{\Delta Q} = P + P \left( \frac{Q}{P} \right) \left( \frac{\Delta P}{\Delta Q} \right)$$

The term on far right is the reciprocal of the elasticity of demand  $1/\epsilon_d$ , measured at the profit-maximizing output, marginal revenue becomes:

$$MR = P + P \left( \frac{1}{\epsilon_d} \right)$$

Now, since the supplier's objective is to maximize profit, we can set marginal revenue

$$P + P \left( \frac{1}{\epsilon_d} \right) = MC$$

equal to MC. Therefore, the equation becomes

or

$$\frac{P - MC}{P} = \frac{1}{\epsilon_d}$$

Equivalently, we can rearrange this equation to express price directly as a markup over marginal cost:

$$P = \frac{MC}{1 + \left( \frac{1}{\epsilon_d} \right)}$$

The above equation tells us that a monopolist charges a price that exceeds a marginal cost, but by an amount that depends inversely on the elasticity of demand. As the above equation shows if demand is extremely elastic,  $\epsilon_d$  is a large negative number,

and price will be very close to marginal cost. Monopoly pricing results in street price of alcohol much higher than its marginal cost.

In the figure 4, price increases by more than the risk cost. This would be impossible in a competitive market, however, it can happen with a monopolist because the relationship between price and marginal cost depends on the elasticity of demand. Suppose, for example, that a monopolist faces a constant elasticity demand curve with elasticity  $-2$ .<sup>19</sup> Markup over marginal cost equation then tells us that price will equal twice MC. With an aggressive enforcement on prohibition, MC increase to  $MC+\rho$ , so the price increases to  $2(MC+\rho) = 2MC+ 2\rho$ . This model predicts that prices rises by twice the amount of  $\rho$  due to monopoly market power. This is consistent with the empirical finding of alcohol prices under Prohibition.

### **Rational Addiction and Effect of Price on Consumption**

In this section, we will summarize Becker-Murphy's (1988) rational addiction model. Unlike conventional wisdom, Becker-Murphy's (B-M) analysis implies that addictive substances are likely to be quite responsive to price. In their Rational Addiction and the Effect of Price on Consumption (1991) paper, they added empirical evidence to support their rational addiction model.

In the B-M model, they assume rational consumers maximize utility from stable preferences as they try to anticipate the future consequences of their choices. They also assume that even strong addicts are rational in the sense that they are forward looking maximizers with stable preferences.

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<sup>19</sup> Cook and Tauchen (1982) estimated that elasticity of demand for alcoholic beverages range from 0 to  $-2$ .

$$U(t) = u[c(t), S(t), y(t)]$$

Where  $U(t)$  is utility at  $t$ ,  $c(t)$  is consumption of the addictive good,  $y(t)$  is a non-addictive good and  $S(t)$  is the stock of “addictive capital” that depends on past consumption  $c$ . They assume that  $u$  is a strongly concave function of  $y$ ,  $c$ , and  $S$ . A simple investment function becomes:

$$\dot{S}(t) = c(t) - \delta S(t) - h[D(t)]$$

Where  $S$  is the rate of change over time in  $S$ ,  $c$  is gross investment in “learning” and  $\delta$  is the instantaneous depreciation rate which measures the exogenous rate of disappearance of the physical and mental effects of past consumption of  $c$  and  $D(t)$  represents expenditures or appreciation. With a length of life equal to  $T$  and a constant rate of time preference,  $\sigma$ , the utility function would be

$$U(0) = \int_0^T e^{-\sigma t} u[y(t), c(t), S(t)] dt$$

Utility is separable over time in  $y$ ,  $c$  and  $S$  but not in  $y$  and  $c$  alone because their marginal utilities depend on past values of  $c$  as measured by  $S$ .

A rational person maximizes utility subject to a constraint on his or her expenditures. If  $A_0$  is the initial value of assets, if the rate of interest ( $r$ ) is constant over time, if earnings at time  $t$  are a concave function of the stock of consumption capital at  $t$ ,  $w(S)$  and if capital markets are perfect, then the budget equation would be

$$\int_0^T e^{-rt} [y(t) + p_c(t)c(t) + p_d(t)D(t)] dt \leq A_0 + \int_0^T e^{-rt} w(S(t)) dt$$

A person maximizes his or her utility subject to this budget constraint and to the investment equation. The value (in utility terms) of the optimal solution,  $V(A_0, S_0, w, p)$  gives the maximization obtainable utility from initial assets  $A_0$ , initial stock of capital  $S_0$ , the earnings function  $w(S)$  and a piece structure  $p(t)$ . The optimal paths of  $y(t)$  and  $c(t)$  are determined by the first-order conditions.

$$a(t) = \int_t^T e^{-(\sigma+\delta)(\tau-t)} u_s d\tau + u \int_t^T e^{-(\gamma+\delta)(\tau-t)} w_s d\tau$$

$$u_c(t) = up_c(t)e^{(\sigma-\gamma)t} - a(t) = \Pi_c(t)$$

$$h_d(t)a(t) = up_d(t)e^{(\sigma-\gamma)t}$$

$$u_y(t) = ue^{(\sigma-\gamma)t}$$

$A(t)$  represents the discounted utility and monetary cost or benefit of additional consumption of  $c$  through the effect on future stocks. It measures the shadow price of an additional unit of stock. Therefore, a rational person recognizes that consumption of a harmful good ( $u_s, w_s < 0$ ) has adverse effects on future utility and earnings. The shadow price of  $c(t)$  is the sum of its market price and the money value of the future cost or benefit of consumption.

It means that if future consumption is held fixed, the absolute value of  $a(t)$  is smaller when the depreciation rate on past consumption ( $\delta$ ) and the rate of preference for the present ( $\sigma$ ) are greater. Consumption of a beneficial  $c$  is smaller when  $\delta$  and  $\sigma$  are greater. Addictive behavior involves both “reinforcement” and “tolerance”.

Reinforcement means that greater past consumption of addictive goods such as alcohol, cigarettes and drugs, increases the desire for present consumption, and tolerance means that when past consumption is greater, the utility from a given amount of consumption is lower. Past consumption of  $c$  affects current utility through “learning by doing” process. Therefore, tolerance is defined by

$$\frac{\partial U}{\partial S} = u_s < 0$$

and it's consumption of addictive goods lowers current utility. Reinforcement ( $dc/dS > 0$ ) requires that increase in past use raise the marginal utility of current consumption:

$$\frac{\partial^2 U}{\partial c \partial S} = u_{cs} > 0$$

Hence, reinforcement for them requires that the positive effect of an increase in  $S(t)$  on the marginal utility of  $c(t)$  is greater than the negative effect of higher  $S(t)$  on the future harm from greater  $c(t)$ . A necessary and sufficient condition for reinforcement near a steady state becomes

$$(\sigma + 2\delta)u_{cs} > -u_{ss}$$

where  $u_{cs}$  and  $u_{ss}$  are local approximations near the steady state,  $\sigma$  is the rate of time preference, and  $\delta$  is the rate of depreciation on addictive capital. Reinforcement is stronger, the bigger the left-hand side is relative to the right-hand side.  $u_{ss} > 0$  is necessary if  $u$  is concave in  $S$  ( $u_{ss} < 0$ ) which means tolerance rises as  $S$  rises. Therefore, an addiction is more likely for people who discount the future heavily (a higher  $\sigma$ ) since they pay less attention to the negative consequences.

Addiction to a good is also stronger when the effects of past consumption depreciate more rapidly ( $\delta$  is larger), for then current consumption has smaller negative effects on future utility. In other words, the harmful effects of smoking, drinking and much drug use do generally disappear within a few years after a person stops the addiction unless vital organs, such as the liver, get irreversibly damaged. The necessary and sufficient condition also implies that the consumption of an addictive food at different times are complements and an increase in either past or expected future prices decrease current consumption.

B-M also demonstrated that rational addicts respond more to price changes in the long run than do non-addicts. The short-run change is smaller than the long run change because the stock of addictive capital is fixed. Even in the short run, however, rational addicts respond to the anticipated growth in future consumption since future and current consumption of addictive goods are complements for them.

B-M also found that a permanent increase in price changes on drugs reduces the current drug use since it increases both present and future price on the drug. However, temporary increases in price due to federal “wars” on drugs has little effect on current drug use since it does not increase future drug prices.

B-M’s finding is also consistent with empirical evidence from early period of Prohibition. When Prohibition was first enacted in 1920, consumers expected alcohol beverage prices to increase (both present and future), and the demand went down in 1921 and 1922. As the price became a bigger share of total cost, long-run changes in demand induced by a given percentage change in the money price get larger relative to the long-run changes in future costs. However, the demand increased again in mid and later years

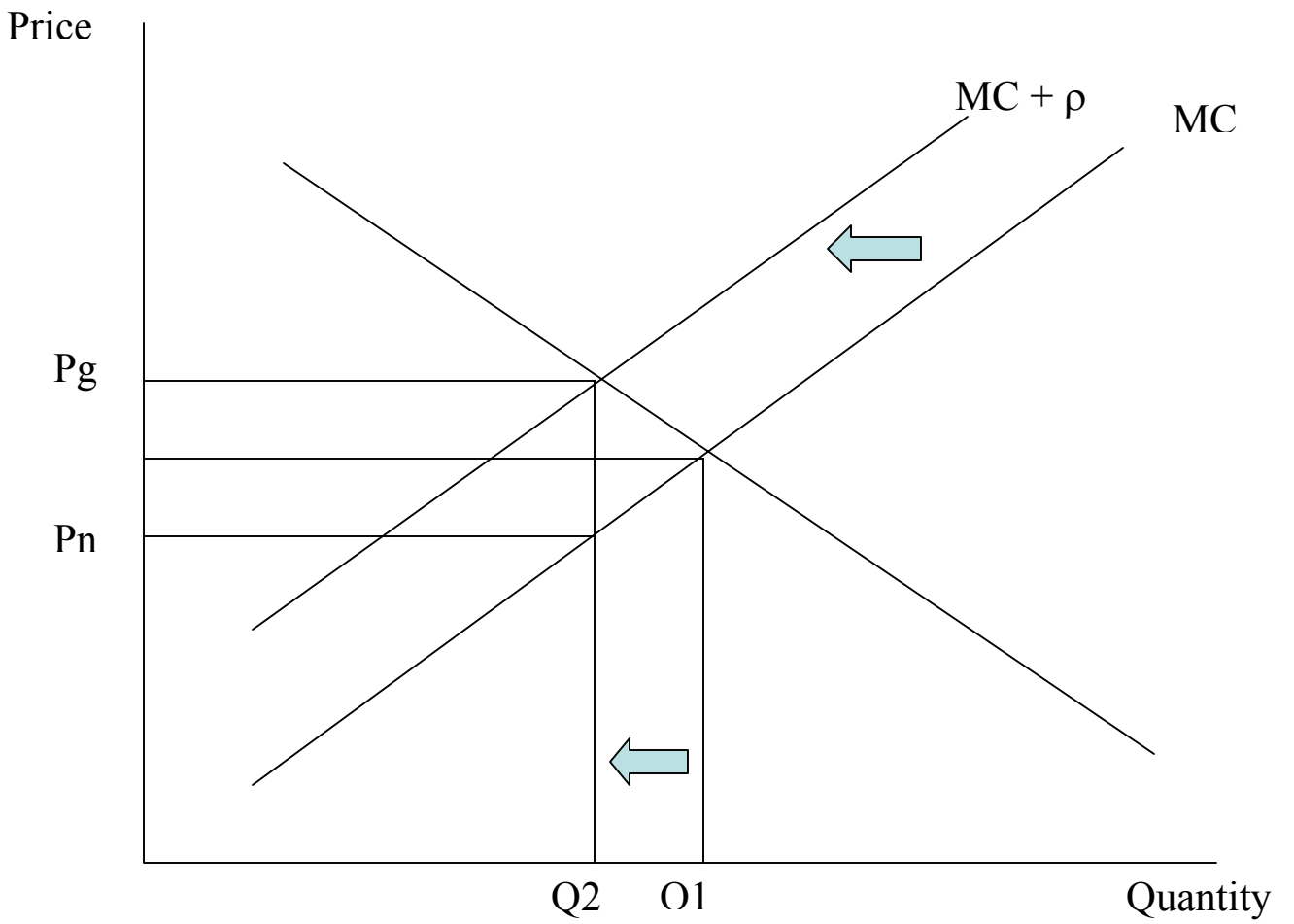
of Prohibition since prices came down due to induced technological change (consumers expected both current and future prices of alcohol to decrease due to technological change). Like the B-M model's prediction, we have found that alcohol Prohibition, which could not keep the prices high in the longer run, did not reduce the aggregate demand for alcohol significantly. Although enforcement costs increased throughout the Prohibition period, the prices decreased and consumption increased again in the longer run.

### **Conclusion**

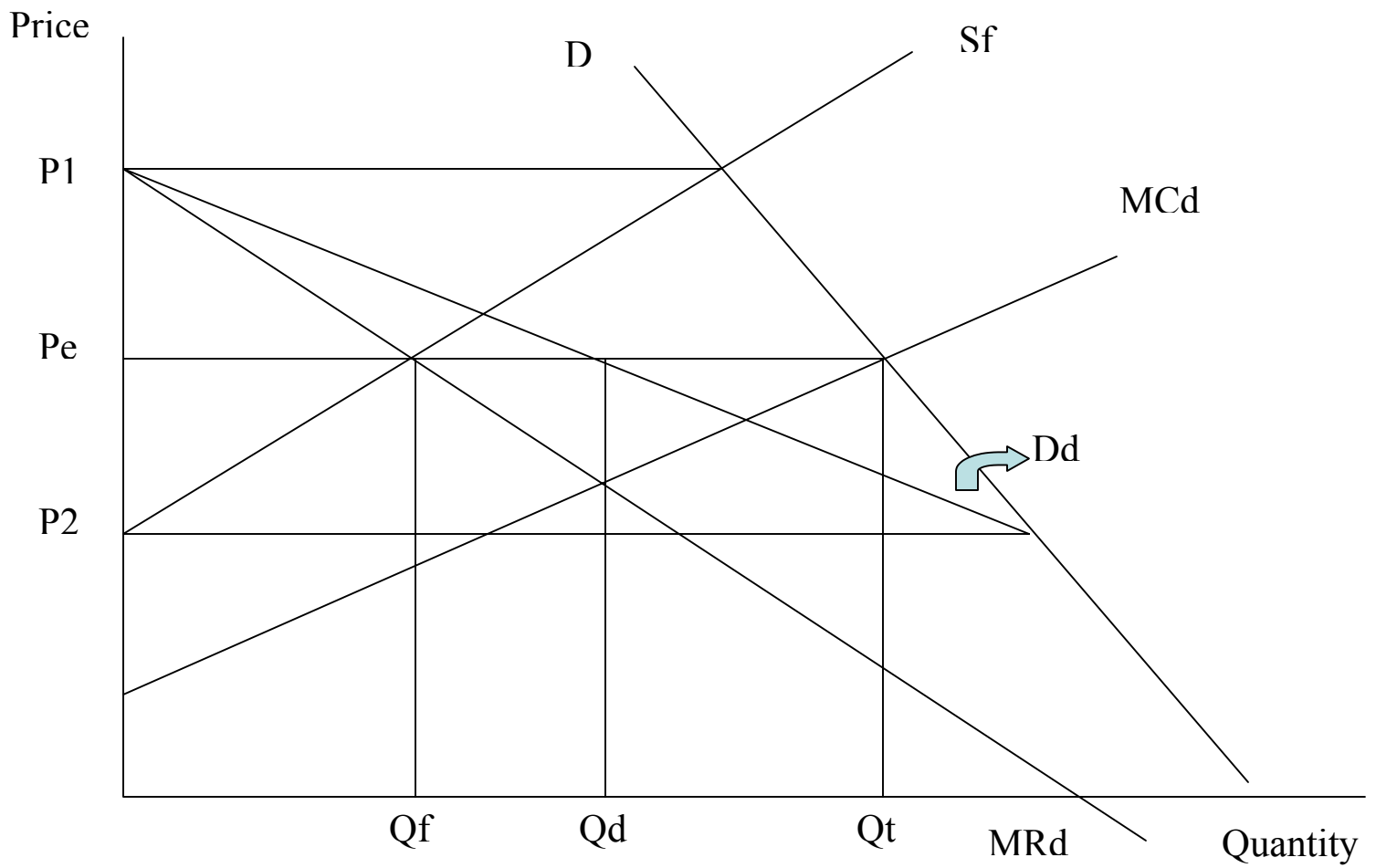
There have been many studies on alcohol consumption during Prohibition. Some studies suggest that alcohol consumption decreased during Prohibition, but there is some controversy over how substantial the effect of Prohibition on consumption was. One possible explanation for controversies over the effectiveness of alcohol Prohibition is that those who argue that Prohibition had significant effects on alcohol consumption tend to focus on the initial results, and those who argue that the Prohibition had little or no effect on aggregate alcohol consumption tend to focus on long run effects.

This study shows that although Prohibition had significant effects on alcohol consumption right after its enactment, it had little or no effect on alcohol consumption in the long run. We have shown that increased in government expenditures induced technological change, and it in turn changed market structure from competitive to monopoly supplier. Monopoly supplier had incentives to recruit and advertise to stimulate market demand and increase its profits. Hence, alcohol Prohibition was unable to keep consumption low, and an unsustainable policy at the end. Like B-M model's prediction, anticipation of higher future prices reduced its consumption in the early

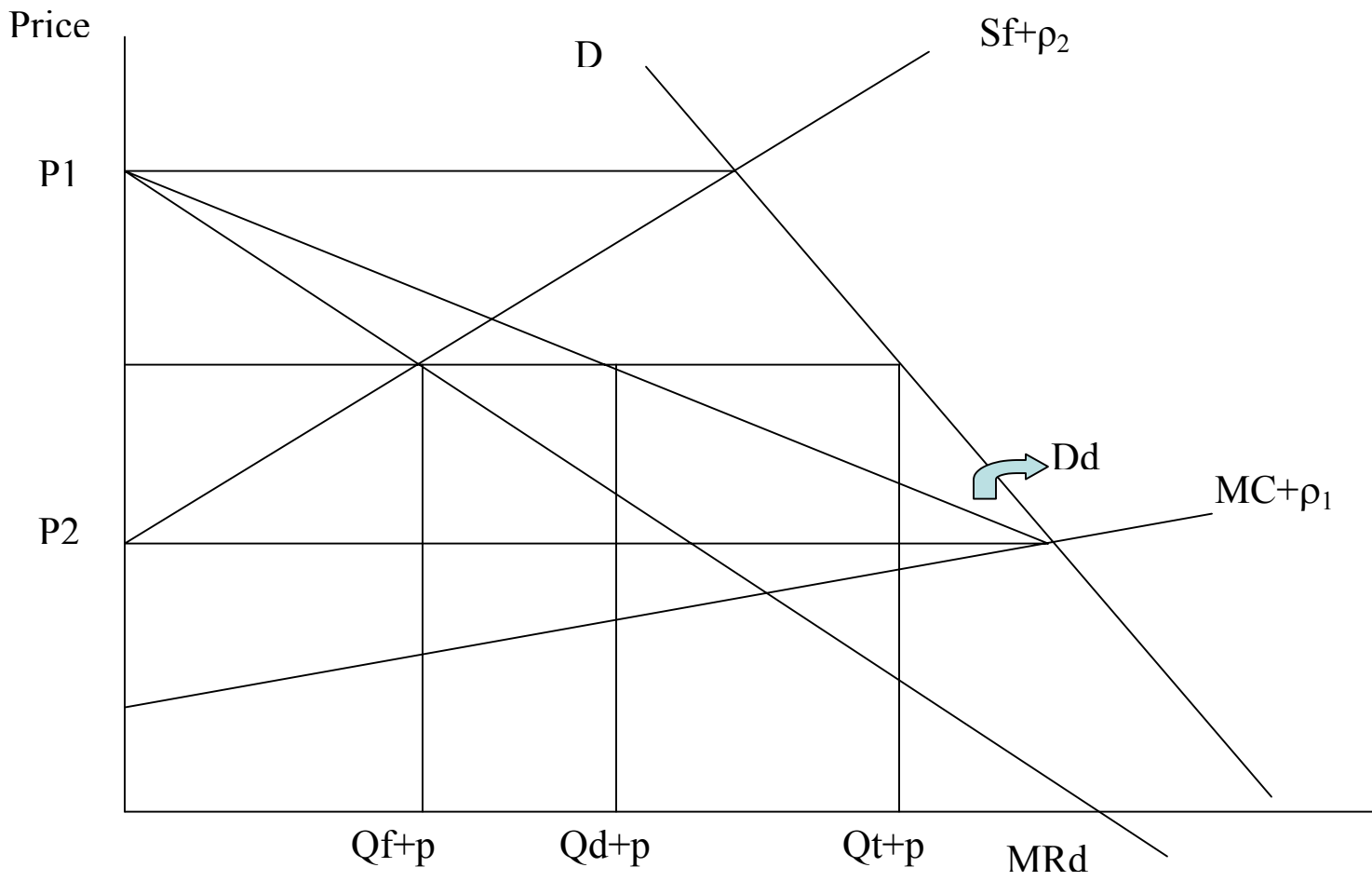
period, and later increased again as both present and expected future prices decreased. In the “War on Drugs”, we have valuable and clear lessons to learn from the experience of Prohibition. Prolonged illegal trade of a substance makes it increasingly difficult to keep prices high, as the industry, sellers in particular, continually find new ways to avoid risks. As the black market adjusted to law enforcement practices, consumption rose again even as enforcement expenditures increased. The lesson from Prohibition is not that public policy is ineffective. On the contrary, public policy has a significant impact on the black market for illegal products.



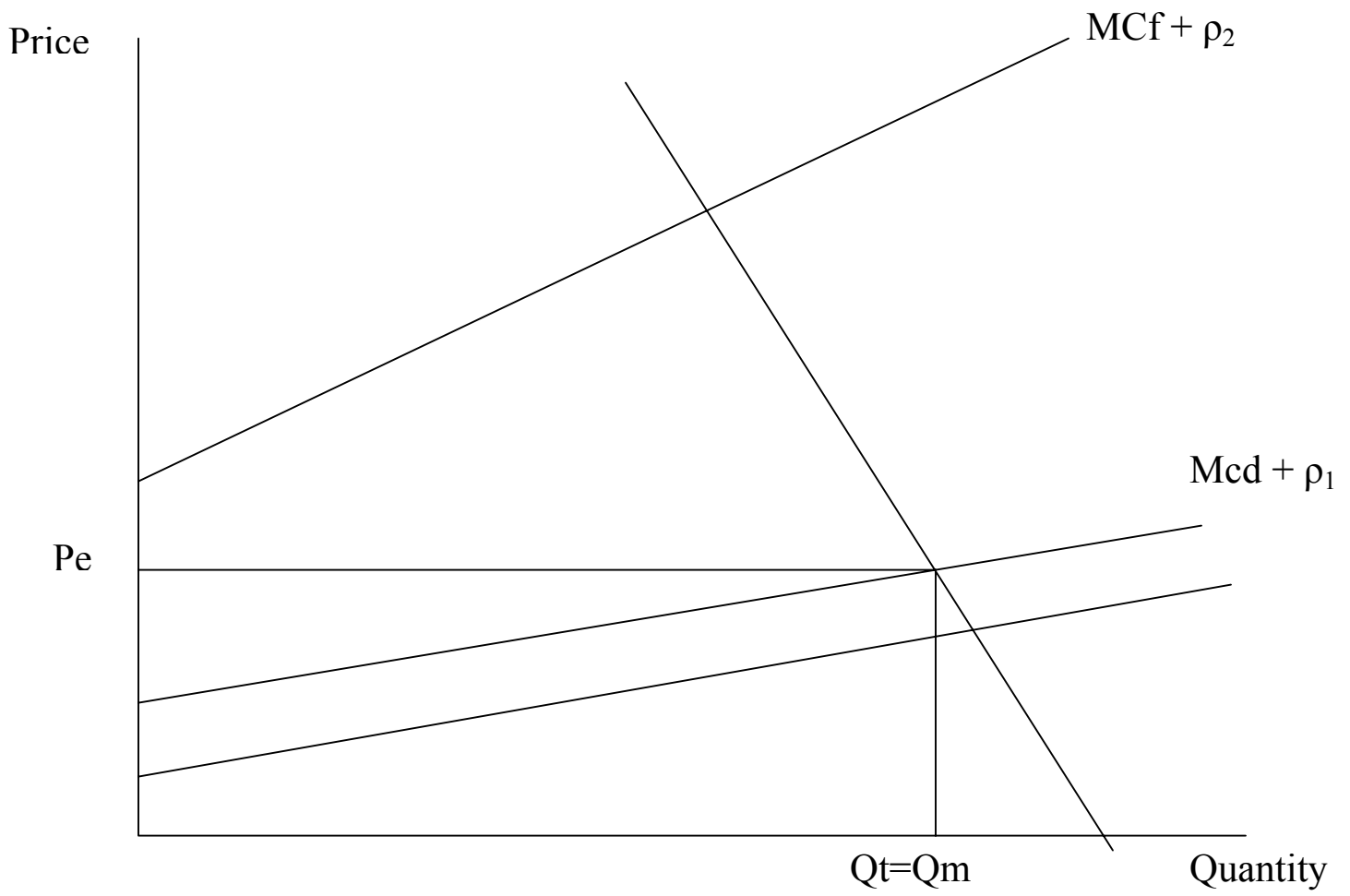
**Figure 1: Competitive Market Case**



**Figure 2: Imperfectly Competitive Market**



**Figure 3: Imperfect Competition with Risk Costs**



**Figure 4: Emergence of Monopoly**

### Appendix One

$$Q = AP^e Y^n$$

Q = Quantity demanded

P = Price

A = Coefficient

Y = Aggregate real income

E = price elasticity = -1.0

N = Income elasticity = 0.7

We estimated price changes during Prohibition by using the formula from above. Actual alcohol quantity demanded and aggregate real income for the year 1919, 1921, 1925 and 1929 are given in Miron and Zwiebel (1991) and Friedman and Schwartz (1982) respectively. We found that when alcohol prices were set for one dollar in 1919, the prices went up to \$3.45 in 1921 but came down to \$1.82 in 1925 and to \$1.78 in 1929. These implied prices include risk cost of manufacturing and selling alcohol during Prohibition.

### Appendix Two

Year	Total pure per Capita (In gallons)	Income per Capita	Implied Price
1919	.80	5922	1.00
1921	.27	5981	2.98
1925	1.16	6782	.75
1929	1.35	7024	.68

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